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Effects of livestock watering sites on alien and native plants in the Mojave Desert, USA

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Abstract

Increased livestock densities near artificial watering sites create disturbance gradients called piospheres. We studied responses of alien and native annual plants and native perennial plants within 9 piospheres in the Mojave Desert of North America. Absolute and proportional cover of alien annual plants increased with proximity to watering sites, whereas cover and species richness of native annual plants decreased. Not all alien species responded the same, as the alien forb *Erodium cicutarium* and the alien grass *Schismus* spp. increased with proximity to watering sites, and the alien annual grass *Bromus madritensis* ssp. *rubens* decreased. Perennial plant cover and species richness also declined with proximity to watering sites, as did the structural diversity of perennial plant cover classes. Significant effects were focused within 200m of the watering sites, suggesting that control efforts for alien annual plants and restoration efforts for native plants should optimally be focused within this central part of the piosphere gradient.

Introduction

Artificial watering sites can have significant ecological effects in arid and semi-arid desert ecosystems where standing surface water is uncommon. One major effect is the focused grazing and activity patterns of large herbivores around artificial watering sites (Andrew, 1988). This focused activity results in a disturbance gradient called a “piosphere” which is centered on the watering site (Lange, 1969). Piosphere gradients have been quantified in terms of large herbivore trail densities (Lange, 1969; Andrew and Lange, 1986a), activity levels (Thrash et al., 1995), and dung accumulations (Lange, 1969; Andrew and Lange, 1986a; Turner, 1998a). They can be created by both wild and domesticated animals and they occur worldwide.

The activity gradient of large herbivores within the piosphere can have many secondary effects. For example, the characteristics of soil nutrients (Tolsma et al., 1987; Perkins and Thomas, 1993; Turner, 1998a, Turner, 1998b), soil compaction (Andrew and Lange, 1986a), microtopography (Nash et al., 2003), cryptogamic crusts (Rogers and Lange, 1971; Andrew and Lange, 1986a), and seedbanks (Navie et al., 1996) can vary with proximity to watering sites. Plant communities vary in biomass, cover, defoliation (Andrew and Lange, 1986b; Tolsma et al., 1987; Soltero et al., 1989; McClaran and Anable, 1992; Fusco et al., 1995; Fernandez-Gimenez and Allen-Diaz, 1999) species composition (Andrew and Lange, 1986b; Tolsma et al., 1987; Tueller and Platou, 1991; Perkins and Thomas, 1993; Nash et al., 1999; but see Van Rooyen et al., 1994 for exceptions), and reproductive output (Riginos and Hoffman, 2003). Generalized “ecosystem health”

can also vary with grazing intensity near artificial watering sites (de Soyza et al., 1997). Although various environmental impacts associated with piospheres have been documented, much information that could help in the management of these impacts is still unknown. Information specific to the effects of piospheres created by domestic livestock is particularly important in the management of rangelands.

The potentially differing distributions of alien and native plants within piospheres are an important topic that deserves more study. Plant invasions into desert regions may be limited by low soil nutrient levels (Brooks, 1999a, Brooks, 2003), and concentrated livestock use can increase availability of soil nutrients (Weir, 1971; Perkins and Thomas, 1993). Livestock also remove plant biomass (e.g. Webb and Stielstra, 1979), which may reduce the ability of native plants to compete with and impede plant invasions. Livestock also serve as dispersal vectors for plants, potentially facilitating the invasion of alien species (Sheeley et al., 2002). Although numerous studies indicate that the abundance of alien species can increase with proximity to artificial watering sites (Andrew and Lange, 1986b; Rogers and Whalley, 1989; Tueller and Platou, 1991; Fusco et al., 1995; Landsberg et al., 1997), some studies reported no relationship (Andrew and Lange, 1986b; McClaran and Anable, 1992). Other issues remain unstudied, such as the response of alien plant communities to grazing gradients within piospheres (e.g. alien richness and covariation among alien species), and the effects of landscape features on alien plant distributions within the piosphere (e.g. shrub–intershrub gradients). This information is needed to design effective early detection and control plans for alien plants near livestock watering sites.

The effect of piospheres on plant species richness is another topic that deserves more attention. In general, intermediate levels of livestock grazing are thought to maximize plant species richness (Sousa, 1984). This hypothesis applies in ecosystems with high productivity where high plant cover may otherwise preclude the coexistence of many species. However, it is unclear if high grazing levels promote plant species richness in ecosystems with low productivity such as deserts. Only two studies of plant species richness are associated with piospheres, and the authors report differing results. Landsberg et al. (1997) reported an absence of consistent trends in species richness within 8 piospheres in Australian rangelands, whereas Fernandez-Gimenez and Allen-Diaz (1999) report that species diversity decreased at a mountain-steppe site, increased at a mid-elevation steppe site, and did not change with proximity to artificial watering sites at a desert-steppe site in Mongolia.

Structural diversity of perennial plants is another landscape variable that has not been described in the context of the piospheres. Structural diversity reflects the variation in numbers (richness) and distribution (evenness) of structural components (cover, height, and volume). High structural diversity of plants is particularly important for birds (Wiens, 1969), and anthropogenic disturbances such as grazing can affect birds (Wiens, 1973) and reptiles (Jones, 1981; Berry, 1997) through changes in vegetation structure in arid and semi-arid ecosystems. These types of data are needed to evaluate the potential effects of vegetation changes on wildlife communities near watering sites.

The objective of this study was to produce new information to better evaluate the ecological effects of piospheres in desert ecosystems. Specifically, we quantified variation in cover and species richness of alien and native annual plant species, and variation in cover, species richness, and structural diversity of perennial plants, within piospheres in the Mojave Desert of western North America. We also evaluated historical land uses that may have simultaneously affected community composition, distribution, and abundance of plants in this region. We predicted that alien annual plant cover and diversity would be higher, whereas native annual and perennial plant cover, species richness, and perennial plant structural diversity would be lower, with increasing proximity to watering sites.

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Study area

This study was conducted within the 194 km^2 Pilot Knob grazing allotment (35°20′30″N, 117°20′28″W), managed by the United States (US) Department of the Interior, Bureau of Land Management (BLM, 1980), in the west-central Mojave Desert, California, USA (Fig. 1). Elevations at the Pilot Knob grazing allotment range from 780 to 1430 m. Rainfall occurs primarily during the winter months of October–April (81% of 168 mm average annual rainfall) as estimated from the Randsburg and Goldstone weather …

Results

During the winter of October 1997 through April 1998, rainfall was 224 mm, or 165% of the long-term average. In contrast, winter rainfall during 1999–2000 was 59 mm, or 43% of the long-term average. Total annual plant cover and species richness were accordingly higher in 1998 (37 point hits/plot, 3 spp./0.02 m^2) than in 2000 (5 point hits/plot, 2 spp./0.02 m^2). …

Discussion

Our results lend support to previous research indicating that artificial watering sites can have significant effects on plant communities in desert ecosystems. We demonstrated positive effects of piospheres on plant cover of aliens, and negative effects on plant cover, species richness, and structural diversity of natives. Richness of alien annual species was the only variable that did not respond significantly to the piosphere gradient. This may have been due to the lesser ability to detect a …

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References (66)

M.H. Andrew

Grazing impact in relation to livestock watering points

Trends in Ecology and Evolution (1988)

M.L. Brooks *et al.*

Dominance and environmental correlates of alien annual plants in the Mojave Desert

Journal Arid Environment (2006)

M. Nash *et al.*

Soil microtopography on grazing gradients in Chihuahuan desert grasslands

Journal of Arid Environment (2003)

I. Thrash *et al.*
Dry season herbivore densities around drinking troughs in the Kruger National Park
Journal of Arid Environment (1995)

N. Van Rooyen *et al.*
Vegetational gradients around artificial watering points in the Kalahari Gemsbok National Park
Journal of Arid Environment (1994)

M.H. Andrew *et al.*
Development of a new piosphere in arid chenopod shrubland grazed by sheep: 1. Changes to the soil surface
Australian Journal of Ecology (1986)

M.H. Andrew *et al.*
Development of a new piosphere in arid chenopod shrubland grazed by sheep: 2. Changes to the vegetation
Australian Journal of Ecology (1986)

K.H. Berry
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Birnie, Jr. R., 1876. Appendix D. Executive report of Lieutenant R. Birnie, Jr., Thirteenth United States Infantry on...

Bleeker, M., 1988. An inventory, analysis and monitoring of grazing in the east Mojave Desert of California: A...

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Cited by (64)

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